CLAIMS

What is claimed is:

1. A device for conditioning a contact surface of a processing pad used in processing microelectronic workpieces, comprising:

an end-effector having a conditioning surface configured to engage the contact surface of the processing pad; and

a plurality of microstructures on the conditioning surface of the end-effector, the microstructures being arranged in a pattern corresponding to a desired pattern of microfeatures on the contact surface of the processing pad, and the microstructures being raised elements projecting from the conditioning surface and/or depressions in the conditioning surface.

2. The device of claim 1 wherein:

the end-effector comprises a plate having a backside with a joint for connecting the plate to a holder and the conditioning surface defines a front side of the plate; and

the microstructures comprise raised features spaced apart from one another in the pattern.

3. The device of claim 1 wherein:

the end-effector comprises a plate and a heater carried by the plate, the plate having a backside with a joint for connecting the plate to a holder and the conditioning surface defines a front side of the plate; and

the microstructures comprise raised features spaced apart from one another in the pattern.

4. The device of claim 1, further comprising a heater carried by the end-effector.

5. The device of claim 1 wherein the end-effector comprises a cylindrical roller and the conditioning surface is cylindrical.

6. The device of claim 1 wherein the end-effector comprises a conical roller and the conditioning surface is conical.

7. The device of claim 1 wherein:

the end-effector comprises a cylindrical roller and the conditioning surface is cylindrical; and

the microstructures comprise raised features spaced apart from one another in the pattern.

8. The device of claim 1 wherein:

the end-effector comprises a conical roller and the conditioning surface is conical; and

the microstructures comprise raised features spaced apart from one another in the pattern.

9. The device of claim 1 wherein the microstructures comprise truncated pyramids spaced apart from one another across the conditioning surface.

10. The device of claim 1 wherein the microstructures comprise posts projecting from the end-effector across the conditioning surface.

11. The device of claim 1 wherein the microstructures comprise rectilinear posts projecting from the end-effector across the conditioning surface.

12. The device of claim 1 wherein the microstructures comprise cylindrical posts projecting from the end-effector across the conditioning surface.

13. The device of claim 1 wherein the microstructures comprise depressions in the end-effector.

14. The device of claim 1 wherein the microstructures comprise mounds projecting from the end-effector.

15. The device of claim 1 wherein the microstructures comprise raised features projecting from the end-effector by a distance of approximately 1 to 500 μm.

16. The device of claim 1 wherein the microstructures comprise raised features that (a) project from the end-effector by a distance of approximately 1 to 500 μm, (b) have a bearing surface of approximately 1 to 200 μm^2, and (c) are spaced apart from each other by approximately 1 to 200 μm.

17. The device of claim 1 wherein:

the end-effector comprises a conical roller and the conditioning surface is conical; and

the microstructures comprise raised features spaced apart from one another in the pattern, the raised features being truncated pyramids.

18. The device of claim 1 wherein:

the end-effector comprises a conical roller having a heater to heat the conditioning surface; and

the microstructures comprise raised features spaced apart from one another in the pattern, the raised features being truncated pyramids.

19. The device of claim 1 wherein:

the end-effector comprises a conical roller and the conditioning surface is conical; and

the microstructures comprise raised features spaced apart from one another in the pattern, the raised features being truncated pyramids that (a) project from the end-

effector by a distance of approximately 1 to 500 μm, (b) have a bearing surface of approximately 1 to 200 μm^2, and (c) are spaced apart from each other by approximately 1 to 200 μm.

20. A device for conditioning a contact surface of a processing pad used in processing microelectronic workpieces, comprising:

an end-effector having a conditioning surface configured to engage the contact surface of the processing pad, the end-effector being a plate; and

a plurality of microstructures on the conditioning surface of the end-effector, the microstructures being arranged in a pattern corresponding to a desired pattern of microfeatures on the contact surface of the processing pad, and the microstructures being raised elements projecting from the conditioning surface and/or depressions in the conditioning surface.

21. The device of claim 20, further comprising a heater carried by the plate.

22. The device of claim 20 wherein the microstructures comprise truncated pyramids spaced apart from one another across the conditioning surface.

23. The device of claim 20 wherein the microstructures comprise posts projecting from the end-effector across the conditioning surface.

24. The device of claim 20 wherein the microstructures comprise depressions in the end-effector.

25. The device of claim 20 wherein the microstructures comprise mounds projecting from the end-effector.

26. The device of claim 20 wherein the microstructures comprise raised features projecting from the end-effector by a distance of approximately 1 to 500 μm.

27. The device of claim 20 wherein the microstructures comprise raised features that (a) project from the end-effector by a distance of approximately 1 to 500 μm, (b) have a bearing surface of approximately 1 to 200 μm^2, and (c) are spaced apart from each other by approximately 1 to 200 μm.

28. A device for conditioning a contact surface of a processing pad used in processing microelectronic workpieces, comprising:

a cylindrical end-effector having a conditioning surface configured to engage the contact surface of the processing pad, the cylindrical end-effector being rotatable about an axis; and

a plurality of microstructures on the conditioning surface of the cylindrical end-effector, the microstructures being arranged in a pattern corresponding to a desired pattern of microfeatures on the contact surface of the processing pad, and the microstructures being raised elements projecting from the conditioning surface and/or depressions in the conditioning surface.

29. The device of claim 28, further comprising a heater carried by the end-effector.

30. The device of claim 28 wherein the microstructures comprise truncated pyramids spaced apart from one another across the conditioning surface.

31. The device of claim 28 wherein the microstructures comprise posts projecting from the end-effector across the conditioning surface.

32. The device of claim 28 wherein the microstructures comprise depressions in the end-effector.

33. The device of claim 28 wherein the microstructures comprise raised features projecting from the end-effector by a distance of approximately 1 to 500 μm.

34. The device of claim 28 wherein the microstructures comprise raised features that (a) project from the end-effector by a distance of approximately 1 to 500 μm, (b) have a bearing surface of approximately 1 to 200 μm^2, and (c) are spaced apart from each other by approximately 1 to 200 μm.

35. A device for conditioning a contact surface of a processing pad used in processing microelectronic workpieces, comprising:

a conical end-effector having a conditioning surface configured to engage the contact surface of the processing pad, the end-effector being rotatable about an axis, and the conditioning surface being a conical surface relative to the axis; and

a plurality of microstructures on the conditioning surface of the conical end-effector, the microstructures being arranged in a pattern corresponding to a desired pattern of microfeatures on the contact surface of the processing pad, and the microstructures being raised elements projecting from the conditioning surface and/or depressions in the conditioning surface.

36. The device of claim 35, further comprising a heater carried by the end-effector.

37. The device of claim 35 wherein the microstructures comprise truncated pyramids spaced apart from one another across the conditioning surface.

38. The device of claim 35 wherein the microstructures comprise posts projecting from the end-effector across the conditioning surface.

39. The device of claim 35 wherein the microstructures comprise depressions in the end-effector.

40. The device of claim 35 wherein the microstructures comprise raised features projecting from the end-effector by a distance of approximately 1 to 500 μm.

41. The device of claim 35 wherein the microstructures comprise raised features that (a) project from the end-effector by a distance of approximately 1 to 500 μm, (b) have a bearing surface of approximately 1 to 200 μm^2, and (c) are spaced apart from each other by approximately 1 to 200 μm.

42. A device for conditioning a contact surface of a processing pad used in processing microelectronic workpieces, comprising:

an end-effector having a conditioning surface configured to engage the contact surface of the processing pad; and

a heater coupled to the end-effector to provide heat to the conditioning surface.

43. The device of claim 42, further comprising microstructures on the conditioning surface.

44. The device of claim 43 wherein the microstructures comprise raised features projecting from the end-effector across the conditioning surface.

45. The device of claim 43 wherein the microstructures comprise depressions in the end-effector.

46. The device of claim 43 wherein the microstructures comprise raised features projecting from the end-effector by a distance of approximately 1 to 500 μm.

47. The device of claim 43 wherein the microstructures comprise raised features that (a) project from the end-effector by a distance of approximately 1 to 500 μm, (b) have a bearing surface of approximately 1 to 200 μm^2, and (c) are spaced apart from each other by approximately 1 to 200 μm.

48. A system for restoring a contact surface of a processing pad used in processing microelectronic workpieces, comprising:

a table for supporting the processing pad;

a carrier assembly having a holder positionable over the table; and

an end-effector carried by the holder, the end effector comprising a conditioning surface configured to engage the contact surface of the processing pad, and a plurality of microstructures on the conditioning surface, the microstructures being arranged in a pattern corresponding to a desired pattern of microfeatures on the contact surface of the processing pad, and the microstructures being raised elements projecting from the conditioning surface and/or depressions in the conditioning surface.

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49. The system of claim 48 wherein:

the end-effector comprises a plate having a backside with a joint for connecting the plate to a holder and the conditioning surface defines a front side of the plate; and

the microstructures comprise raised features spaced apart from one another in the pattern.

50. The system of claim 48, further comprising a heater carried by the end-effector.

51. The system of claim 48 wherein the end-effector comprises a cylindrical roller and the conditioning surface is cylindrical.

52. The system of claim 48 wherein the end-effector comprises a conical roller and the conditioning surface is conical.

53. A system for restoring a contact surface of a processing pad used in processing microelectronic workpieces, comprising:

a table for supporting the processing pad;

a carrier assembly having a holder positionable over the table; and

an end-effector carried by the holder, the end effector comprising a plate having a conditioning surface configured to engage the contact surface of the processing pad and a plurality of microstructures on the conditioning surface, the microstructures being spatially arranged in a pattern corresponding to a desired pattern of microfeatures to be imparted on the contact surface of the processing pad, and the microstructures being raised elements projecting from the conditioning surface and/or depressions in the conditioning surface.

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54. The system of claim 53, further comprising a heater carried by the end-effector.

55. A system for restoring a contact surface of a processing pad used in processing microelectronic workpieces, comprising:

a table for supporting the processing pad;

a carrier assembly having a holder positionable over the table; and

an end-effector carried by the holder, the end effector comprising a cylindrical conditioning surface configured to engage the contact surface of the processing pad and the end-effector being rotatable about an axis, and the end effector further including a plurality of microstructures on the conditioning surface, the microstructures being spatially arranged in a pattern corresponding to a desired pattern of microfeatures to be imparted on the contact surface of the processing pad, and the microstructures being raised elements projecting from the conditioning surface and/or depressions in the conditioning surface.

56. The system of claim 55, further comprising a heater carried by the end-effector.

57. A system for restoring a contact surface of a processing pad used in processing microelectronic workpieces, comprising:

a table for supporting the processing pad;

a carrier assembly having a holder positionable over the table; and

an end-effector carried by the holder, the end effector comprising a conical conditioning surface configured to engage the contact surface of the processing pad and the end-effector being rotatable about an axis, and the end-effector further having a plurality of microstructures on the conditioning surface, the microstructures being spatially arranged in a pattern corresponding to a desired pattern of microfeatures to be imparted on the contact surface of the processing pad, and the microstructures being raised elements projecting from the conditioning surface and/or depressions in the conditioning surface.

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58. The system of claim 57, further comprising a heater carried by the end-effector.

59. A system for restoring a contact surface of a processing pad used in processing microelectronic workpieces, comprising:

a table for supporting the processing pad;

a carrier assembly having a holder positionable over the table;

an end-effector carried by the holder, the end effector comprising a conditioning surface configured to engage the contact surface of the processing pad; and

a heat source coupled to the end-effector to provide heat to the conditioning surface.

60. The system of claim 59, further comprising microstructures on the conditioning surface.

61. The system of claim 60 wherein the microstructures comprise raised features projecting from the conditioning surface.

62. The system of claim 60 wherein the microstructures comprise depressions in the conditioning surface.

63. The system of claim 59 wherein the end-effector comprises a plate.

64. The system of claim 59 wherein the end-effector comprises a cylindrical roller.

65. The system of claim 59 wherein the end-effector comprises a conical roller.

66. The system of claim 59 wherein the holder comprises an arm and the carrier further comprises a rotary drive unit connected to the arm to rotate the arm, and wherein the end-effector is attached to the arm.

67. A processing machine for processing microelectronic workpieces, comprising:

a table;

a processing pad coupled to the table, the processing pad comprising a planarizing medium having a contact surface defined by a plurality of microfeatures having bearing surfaces;

a microelectronic workpiece support assembly having a head for holding a microelectronic workpiece and a drive mechanism connected to the head, the drive mechanism controlling the head to move the microelectronic workpiece with respect to the processing pad;

a carrier assembly having a holder positionable over the processing pad; and

an end-effector carried by the holder, the end effector comprising a conditioning surface configured to engage the contact surface of the processing pad, and a plurality of microstructures on the conditioning surface, the microstructures being spatially arranged in a pattern corresponding to a desired pattern of microfeatures to be imparted on the contact pad, and the microstructures being raised elements projecting from the conditioning surface and/or depressions in the conditioning surface.

68. The machine of claim 67 wherein:

the end-effector comprises a plate having a backside with a joint for connecting the plate to the holder and the conditioning surface defines a front side of the plate; and

the microstructures comprise raised features spaced apart from one another in the pattern.

69. The machine of claim 67 wherein:

the end-effector comprises a plate and a heater carried by the plate, the plate having a backside with a joint for connecting the plate to the holder and the conditioning surface defines a front side of the plate; and

the microstructures comprise raised features spaced apart from one another in the pattern.

70. The machine of claim 67, further comprising a heater carried by the end-effector.

71. The machine of claim 67 wherein the end-effector comprises a cylindrical roller and the conditioning surface is cylindrical.

72. The machine of claim 67 wherein the end-effector comprises a conical roller and the conditioning surface is conical.

73. The machine of claim 67 wherein:

the end-effector comprises a cylindrical roller and the conditioning surface is cylindrical; and

the microstructures comprise raised features spaced apart from one another in the pattern.

74. The machine of claim 67 wherein:

the end-effector comprises a conical roller and the conditioning surface is conical; and

the microstructures comprise raised features spaced apart from one another in the pattern.

75. The machine of claim 67 wherein the microstructures comprise truncated pyramids spaced apart from one another across the conditioning surface.

76. The machine of claim 67 wherein the microstructures comprise posts projecting from the end-effector across the conditioning surface.

77. The machine of claim 67 wherein the microstructures comprise rectilinear posts projecting from the end-effector across the conditioning surface.

78. The machine of claim 67 wherein the microstructures comprise cylindrical posts projecting from the end-effector across the conditioning surface.

79. The machine of claim 67 wherein the microstructures comprise depressions in the end-effector.

80. The machine of claim 67 wherein the microstructures comprise mounds projecting from the end-effector.

81. The machine of claim 67 wherein the microstructures comprise raised features projecting from the end-effector by a distance of approximately 1 to 500 μm.

82. The machine of claim 67 wherein the microstructures comprise raised features that (a) project from the end-effector by a distance of approximately 1 to 500 μm, (b) have a bearing surface of approximately 1 to 200 μm^2, and (c) are spaced apart from each other by approximately 1 to 200 μm.

83. The machine of claim 67 wherein:

the end-effector comprises a conical roller and the conditioning surface is conical; and

the microstructures comprise raised features spaced apart from one another in the pattern, the raised features being truncated pyramids.

84. The machine of claim 67 wherein:

the end-effector comprises a conical roller having a heater to heat the conditioning surface; and

the microstructures comprise raised features spaced apart from one another in the pattern, the raised features being truncated pyramids.

85. The machine of claim 67 wherein:

the end-effector comprises a conical roller and the conditioning surface is conical; and

the microstructures comprise raised features spaced apart from one another in the pattern, the raised features being truncated pyramids that (a) project from the end-effector by a distance of approximately 1 to 500 μm, (b) have a bearing surface of approximately 1 to 200 μm^2, and (c) are spaced apart from each other by approximately 1 to 200 μm.

86. A processing machine for processing microelectronic workpieces, comprising:

a table;

a processing pad coupled to the table, the processing pad comprising a planarizing medium having a contact surface;

a microelectronic workpiece support assembly having a head for holding a microelectronic workpiece and a drive mechanism connected to the head, the drive mechanism controlling the head to move the microelectronic workpiece with respect to the processing pad;

a carrier assembly having a holder positionable over the processing pad;

an end-effector having a conditioning surface configured to engage the contact surface of the processing pad; and

a heater coupled to the end-effector to provide heat to the conditioning surface.

87. The machine of claim 86, further comprising microstructures on the conditioning surface.

88. The machine of claim 87 wherein the microstructures comprise raised features projecting from the end-effector across the conditioning surface.

89. The machine of claim 87 wherein the microstructures comprise depressions in the end-effector.

90. The machine of claim 87 wherein the microstructures comprise raised features projecting from the end-effector by a distance of approximately 1 to 500 μm.

91. The machine of claim 87 wherein the microstructures comprise raised features that (a) project from the end-effector by a distance of approximately 1 to 500 μm, (b) have a bearing surface of approximately 1 to 200 μm^2, and (c) are spaced apart from each other by approximately 1 to 200 μm.

92. In the processing of a microelectronic workpiece, a method for conditioning a processing pad having a contact surface used in planarizing and/or deposition processes, comprising reforming microfeatures on the contact surface by embossing a pattern of the microfeatures on the contact surface.

93. The method of claim 92 wherein embossing a pattern of the microfeatures comprises pressing an end-effector against the contact surface, the end-effector having a conditioning surface and a plurality of microstructures on the conditioning

surface, and the microstructures being arranged to produce the pattern of microfeatures on the contact surface of the pad.

94. The method of claim 93 wherein the end-effector comprises a plate having a face defining the conditioning surface, and wherein pressing an end-effector against the contact surface comprises driving the face of the plate against the contact surface.

95. The method of claim 93 wherein the end-effector comprises a cylindrical roller having a cylindrical surface defining the conditioning surface, and wherein pressing an end-effector against the contact surface comprises rolling the conditioning surface across the contact surface.

96. The method of claim 93 wherein the end-effector comprises a conical roller having a conical surface defining the conditioning surface, and wherein pressing an end-effector against the contact surface comprises rolling the conditioning surface across the contact surface.

97. The method of claim 92, further comprising heating the processing pad.

98. The method of claim 97 wherein embossing a pattern of the microfeatures comprises pressing an end-effector against the contact surface, the end-effector having a conditioning surface and a plurality of microstructures on the conditioning surface, and the microstructures being arranged to produce the pattern of microfeatures on the contact surface of the pad.

99. The method of claim 98 wherein the end-effector comprises a plate having a face defining the conditioning surface, and wherein pressing an end-effector against the contact surface comprises driving the face of the plate against the contact surface.

100. The method of claim 98 wherein the end-effector comprises a cylindrical roller having a cylindrical surface defining the conditioning surface, and wherein pressing an end-effector against the contact surface comprises rolling the conditioning surface across the contact surface.

101. The method of claim 98 wherein the end-effector comprises a conical roller having a conical surface defining the conditioning surface, and wherein pressing an end-effector against the contact surface comprises rolling the conditioning surface across the contact surface.